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Development of hydraulic operated tamarind briquetting machine

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Abstract
The objective of this study was to evaluate the performance of Hydraulic operated Tamarind Briquetting Machine under different moisture levels of tamarind pulp and application of different constant pressure at each stroke. The test results indicated a satisfactory working of the prototype. The average density of briquettes varied from 0.94 to 1.03 g/cm3 for 500gm and 0.99 to 1.14 for 1000gm.It was also observed that the tamarind pulp, having moisture content 18.14 to 26.70% (wb) was suitable for briquetting. It was possible to obtain a final density (1.14 g/cm3) of briquette at a constant pressure of 43149 kPa at each stroke. The capacity of prototype of tamarind briquetting machine was found to be 45 number of briquettes per hour for 500 g briquette and 35 number of briquettes per hour for 1 kg briquette. The breakeven point was estimated to be 922.005 number of briquettes per year for 1 kg briquettes and 622.12 number of briquettes per year for 500 g briquettes. The payback period is estimated to be 1.28 year for 1 kg briquettes and 0.47year for 500 g briquettes.

Keywords: Briquettes Density, Briquetting Machine, Processing, Tamarind and Value Addition

Introduction
India is the world’s largest producer of tamarind. Out of 52 spices under the preview of Spices Board, India, tamarind is at the fifth position in terms of export in the year (2013-2014). The tree mostly grown wild, although it is cultivated to a limited extent.Tamarind *(Tamarindus indica* L.) is a socially and economically important fruit of India as well as Chhattisgarh. In Chhattisgarh, the yearly production of tamarind is 50,000 tonnes out of which about 10.000 tones are used for processing and sold to other states (Anon, 2007) [1]. During selling the rural people come across many problems such as handling of large volume which need significant space, consumer acceptability for its quality, high transformation cost etc. To overcome these problems there is a need of densification of the stock which can be a accomplished by converting pulp into small briquettes. The machine is supposed to reduce the volume of seedless tamarind pulp which reduce the space requirement, reduce the tendency of darkening effect, provide suitable handling size, provide ease in packaging, improve the appearance of pulp and finally result in value addition of the uncompressed tamarind pulp. A hydraulic operated tamarind briquetting machine would be beneficial as it does not require any fuel like electricity or animal power (Walaipon, 2009; Oumarou and Oluwole, 2010) [9]. Hydraulics is the science of transmitting force or motion through the medium of a confined liquid. In a hydraulic device, power is transmitted by pushing on a confined liquid. The transfer of energy takes place because a quantity of liquid is subject to pressure. The advantages of the hydraulic system are: smoothness, control of wide range of speed and forces, overload protection, simple maintenance and flexibility (Rana *et al.*, (2013). Hydraulic systems have been used in industry in a wide number of applications by virtue of their small size to power ratios and the ability to apply very large force and torque, to make it easier, safer & simple. The device should also be easy to operate by the unskilled villagers which will not only solve the above problems to certain extent but at the same time it may provide oppurtunities in gearing their livelihood in a better way.

Material and Methods
Design considerations
The Hydraulic tamarind briquetting machine has been designed with the following consideration. The machine should be of light weight and easy to operate & transport. A hydraulic jack and hamp pump with reservoir will be provided to the machine so that the operator should be able to transfer the body weight on handle and then by the principle of pascles law the hydraulic force will work and upper die will lay down through hydraulic jack by the help of hydraulic pipe. The tamarind pulp will be densified in the form of cuboid & pulp box should hold sufficient quantity of tamarind pulp, 1kg or 500 as per the requirement.

Material Selection

The hydraulic tamarind briquetting machine was made of locally available materials to keep the cost low.The study was conducted, designed and fabricated in Swami Vivekananda College of Agricultural Engineering. IGKV, Raipur (CG) situated at $21^0\ 14^0\ 02'$ N latitude. The operational field meant for the study was selected from the demonstration / research field of the capacity. Thw main parts include mainframe, hydraulic jack, upper die, pulpbox, base plate,hand pump with reservoir, hydraulic oil, hydraulic pipe (fig1.) M.S Angle iron of size 40*40*5 was used for the fabrication of main frame. It was strengthened by joining the angle iron pieces edge to edge and welded together. Upper die is made of iron sheet of dimensions 188*123*16 mm. In this experiment 2 type of pulp box (for 1 kg and 500 g of uncompressed tamarind pulp) were used. 1kg pulp box was made of 2 pieces of iron sheet of size 190*115*6 mm and 2 pieces of iron sheet of size 137*115*6 mm.500g pulp box was made of 2 pieces of iron sheet of size 137*80*6 mm and 2 pieces of iron sheet of size 137*80*6 mm. These plate were welded together. Hydraulic jack was purchased from the market and it works with the pressure of 44057 kg/cm ^{2} total capacity is 5 tonnes its extended height is having 360 mm and it weight is about 2.9 kg. The pulp box were opened at both top and bottom side for loading of uncompressed tamarind pulp and unloading of tamarind briquettes. The wooden plates was used in the pulp box to act as sliding mechanism. Base plate made of iron sheet, having dimensions 460*200*12 mm. angle iron having length of 680 mm was located just below and centre of main frame. A hand pump with reservoir having dimensions of 150*180*180 mm and having capacity is about 2.5 kg/h is fitted from right side of the frame, 2 pieces of iron sheet of size 45mm is welded both the sides and the distance between the iron sheets is 78mm and 4 screw is welded with 4 sides of the reservoir and fitted with bolts.

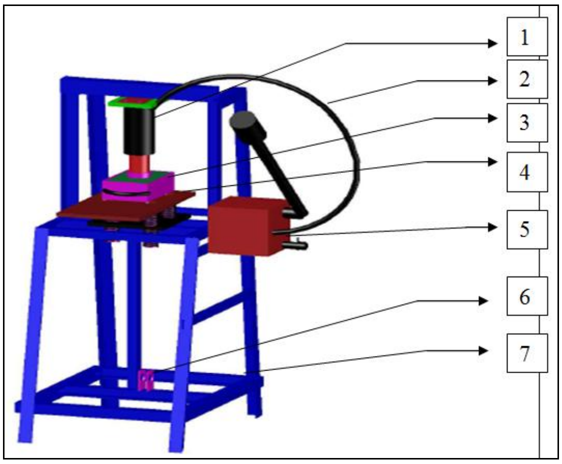

Fig 1: D view of hydraulic operated tamarind briquetting machine

1. Hydraulic Jack
2. Hydraulic Pipe
3. Pulp Box
4. Base Plate
5. Reservoir with Hand pump
6. Angle Iron
7. Frame

Procedure for testing

Different moisture content tamarind pulps were taken for testing of tamarind briquetting machine. The machine was operated by any operators. 3 replications were done by each operator at a time. Counting the number of stroke while each briquetting process. During each stroke the force (kg) applied by operator was standard because it's a hydraulic machine and resident time (s) was measured by the stopwatch. Developed depth (cm) on pulp box due to applied force was measured with measuring scale after each stroke. Pressure was already calculated from the standard technical specifications chart from vankos hydraulic and area of pulp box. Thickness of tamarind briquette was estimated by the following expression.

$$\text{Volume}=L_b \times W_b \times T_b \qquad ....(1)$$

Where, L_b, W_b, and T_b was length (cm), breadth(cm) and thickness(cm) of the briquettes respectively.

$$\text{Density}= \frac{M}{V} \qquad ....(2)$$

Where, M_b and V_b was mass (g) and volume $(cm)^3$ of the briquette respect tively.

$$\text{Compression ratio} = \frac{V_i}{V_f} \qquad ...(3)$$

Where, v_i and v_f was initial and final volume $(cm)^3$ of the briquette respectively.

Statistical Analysis

Split plot design was used to determine the Analysis of variances. The data of various characters under study were analysed as described

Results and Discussion

Density of tamarind briquette at different stroke using 500 g and 1 kg tamarind pulp

The density of 500 g and 1 kg uncompressed tamarind was 0.42 g/cm^3 and 0.9 g/cm^3. For 500 g tamarind briquette the total number of fourth stroke was required to all samples. After applying pressure by one operator at first stroke the average density of briquette was increases from 0.78 g/cm^3. At the second stroke the density of briquette was further increased to 0.82 g/cm^3. At the third stroke the thickness of briquette was increased to 0.88 g/cm^{3}and the fourth stroke the thickness of briquette was increased to 0.94 g/cm^3. The compression ratio was observed to be 2.5:1 of each replication. The Fig.1 shows that the density of tamarind briquettes, having different moisture content, at different stroke. Tamarind pulp moisture content (wb) was 21.10 %, 18.14 %, 15.10 % and 26.70 % after completion of fourth stroke, the average density of briquettes was found to be 0.94, 0.90, 89 and 1.03 g/cm^3 and compression ratio was calculated to be 2.48, 2.6, 2.50 and 2.66 respectively.

In case of 1 kg tamarind briquette the total number of six strokes was required to samples. After applying pressure by one operator at first and second stroke the density of briquette was increases from 0.50 g/cm^3 and 0.56 g/cm^3. At the third and fourth stroke the density of briquette was further increased to 0.66 g/cm^3 and 0.78 g/cm^3. At the fifth stroke the thickness of briquette was increased to 0.87 g/cm^3 and the six strokes the thickness of briquette was increased to 0.98 g/cm^3. The compression ratio was observed to be 2.5:1 of each replication.

The Fig. 2 shows that the density of tamarind briquettes, having different moisture content, at different stroke.

Tamarind pulp moisture content (wb) was 21.10 %, 18.14 %, 15.10 % and 26.70 % after completion of six strokes, the average density of briquettes was found to be 0.99, 0.93, 0.96 and 1.14 g/cm^3.

It was observed that when the moisture content of tamarind pulp decreases, the hardness of the tamarind pulp increases. Hence the briquetting process made difficult. On other hand when the moisture content of tamarind pulp increases, the hardness of tamarind pulp decreases that will make briquetting process easier. From the Fig. 4.3 it was observed that the tamarind pulp, having moisture content (wb) 18.14 % to 26.70 % was better for briquetting.

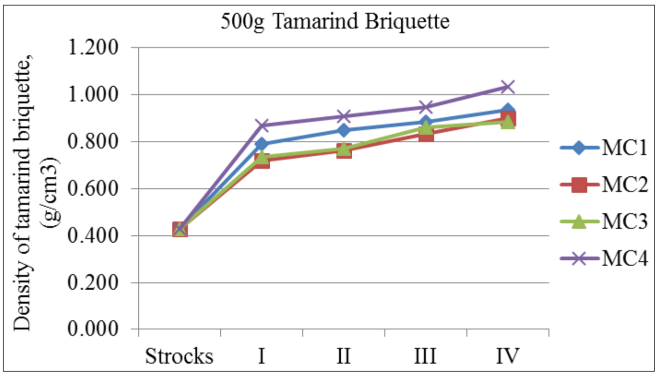

Fig 2:

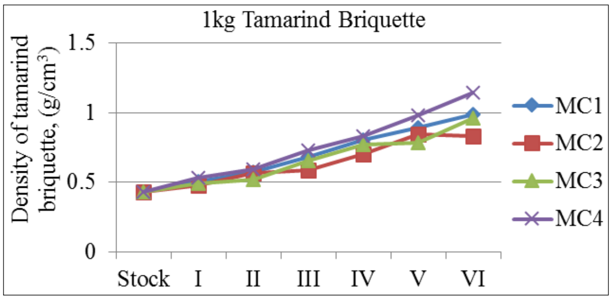

Fig 3:

Statistical Analysis for Observed Data

Effect of pressure applied by operators

It was observed that there was no significant difference among the moisture content of tamarind pulp in respect of pressure developed. The effect of number of stroke was also analyzed and there is no difference on pressure. The interaction effect of moisture content of tamarind pulp and number of stroke was also found constant in terms of pressure. The operators used for testing of tamarind briquetting machine were also statistically compared and it was also found constant. The combined effect of stroke, operator and moisture content was also analyzed and this interaction has constant effect in terms of pressure.

Table 1: ANOVA table for density of tamarind briquettes (500g)

S.V	d.f.	SS	MSS	Computed F value		Tabular F value at 5%
Replication	2	0.00	0.00			
Main plot (S)	3	0.18	0.06	87.17		8.94
Error (s)	6	0.00	0.00			
Sub plot (MC)	3	0.14	0.05	66.57		8.64
SxMC	9	0.01	0.00	1.00		2.9
Error (mc)	24	0.02	0.00			
Total	47	0.35				
CD					CV,%	
Main plot				0.03	CV (a)	3.06
Sub plot				0.02	CV (b)	3.11
Sub plot at same level of main plot				NS		
Main plot at same or different level of sub plot				NS	Mean	0.86

Table 2: ANOVA table for density of tamarind briquettes (1kg)

S.V	d.f.	SS	MSS	Computed F value		Tabular F value at 5%
Replication	2	0.00	0.00			
Main plot (A)	5	2.04	0.41	4031.87		4.75
Error (a)	10	0.00	0.00			
Sub plot (B)	3	0.18	0.06	575.91		17.38
AxB	15	0.10	0.01	63.18		4.77
Error (b)	36	0.00	0.00			
Total	71	2.33				
CD					CV,%	
Main plot				0.01	CV (a)	1.38
Sub plot				0.01	CV (b)	1.42
Sub plot at same level of main plot				0.02		
Main plot at same or different level of sub plot				0.02	Mean	0.73

Density of tamarind briquettes after each stroke

Density of tamarind briquettes after each stroke was also analyzed statistically and ANOVA table is presented in Table 4.7 and Table 4.8. It was observed that there was significant difference among the moisture content of tamarind pulp in respect of density of tamarind briquette. The effect of number of stroke was also analyzed and the differences were significant. The interaction effect of moisture content of tamarind pulp and number of stroke was also found significant in terms of density of tamarind briquette. The operators used for testing of tamarind briquetting machine were also statistically compared and it was also found significant. The combined effect of stroke and moisture content of tamarind pulp was also analyzed and this interaction has significant in terms of density of tamarind briquette.

Capacity and economic evaluation of Hydraulic tamarind briquetting machine

The capacity of tamarind briquetting machine was 45 number of briquettes/h 500g briquette and 35 number briquettes/h for 1 kg briquette. The cost of briquetting was estimated to be 1.07 Rs/kg for 1 kg briquette and 2.33 Rs/kg for 500 g briquette.

Conclusion

Performance of Hydraulic Tamarind Briquetting Machine" was found to be satisfactory under the wide range of moisture content of tamarind pulp. The density and compression ratio of both type briquettes (500g and 1 kg) was found to be 1.03 g/cm3 and 2.6:1 respectively. It was possible to obtain a final density (1.03 g/cm3) of briquette at a constant pressure of 43149 kPa at each stroke. And it was observed that the capacity of tamarind briquetting machine was 88 % and 92% more than the capacity of briquetting by hammering action for 500 g and 1 kg briquettes respectively.

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